Method for qualizing temperature differences in molten glass, and equipment ~~herefor~~

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a method for equalizing temperature differences in molten glass upstream from a tap-off point at which the glass is tapped into a mould in a forming machine. Moreover, the invention relates to an equalizer, i.e. a channel in which temperature differences in the glass melt are equalized, said channel having its outlet at the tap-off point.

DESCRIPTION OF RELATED ART

In the production of glass products such as glass bottles and containers of different types, it is of prime importance for the glass melt to have a predetermined and uniform weight and viscosity. If the weight and viscosity are not uniform, the yield drops sharply. This is because the molds ~~moulds~~ are not filled sufficiently, and as a result the glass bottles do not have sufficient wall thickness and do not have the necessary strength.

The glass is melted in a glass furnace from which it is transported in the liquid state via a number of transport channels. In these transport channels, attempts are made to maintain a predetermined glass temperature while keeping the temperature in the glass melt as uniform as possible. Each transport channel leads into a so-called equalizer which comprises a relatively short channel with a typical length of a few meters ~~metres~~ or so. The purpose of the equalizer is to keep the glass melt at a very uniform temperature.

The viscosity of the glass is highly dependent on temperature. Consequently, local temperature differences in the transport channel, and particularly in the equalizer, will heavily influence production yield calculated as the weight of the produced products vis-a-vis the weight of the glass melt that leav s the tap-off point.

In conventional transport channels and qualizers, a mixture of heating zones and cooling zones is used along the transport channel and equalizer. The intention is to first cool the glass to an appropriate casting temperature and then equalize the temperature in the glass melt at the predetermined casting temperature so that it is uniform throughout a cross section of the glass melt taken at right angles to the longitudinal direction of the equalizer. The cooling zones usually comprise zones where no heating takes place. Instead, the glass melt is permitted to cool down naturally. The heating zones usually incorporate heating with a gas burner, and here the flue gas sweeps along the exposed top surface of the glass melt, but resistor heating elements are also placed along the channel walls. In addition, molybdenum electrodes are inserted in the channels in such a way that the electrodes are surrounded by the glass melt, and electric current flows through the glass melt between the two electrodes.

In conventional facilities, the glass melt temperature is measured at a number of discrete points in the glass melt using thermocouples. These measured values are used to control the heating equipment. Experience has shown that it does not suffice to measure the temperature at a number of discrete points and, on this basis, control the heating equipment, due to the fact that there are still local temperature gradients at the outer boundary surfaces of the glass melt.

The present invention solves this problem and comprises a method and equipment that provide a significantly more uniform temperature in the glass melt than provided by conventional technology, and this in turn provides a substantial increase in yield.

SUMMARY OF THE INVENTION

The present invention thus relates to a meth d for equalizing temperature differences in molten glass in at least ne temperature equalization zone in the form f a channel intended to transport a glass melt, said zone being located upstream

from a tap-off p int at which the glass is tapped into a mould in a forming machine or the like. ~~, characterized in that~~ Resistor ~~resistor~~ heating elements are provided in the temperature equalization zone walls, bottom and roof, and ~~in that~~ the temperatures of the surfaces of the respective walls, bott m and roof contacted by the resistor heating elements are caused to be measured. The ~~, and in that the said~~ resistor heating elements are ~~caused to be~~ controlled by an electric controller so that the temperatures of said surfaces are ~~caused to be~~ equal to or largely equal to a predetermined tapping temperature of the glass melt.

Moreover, the invention also relates to ~~an~~ temperature equalizer ~~of the type and with the general characteristics set forth in claim 7~~ apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

Below, the invention is described in greater detail, partially in connection with the attached drawings which show examples of embodiments of the invention, and in which:

- Fig. 1 shows a cross-section taken in the longitudinal direction of a part of a temperature equalization zone in accordance with the invention.
- Fig. 2 shows a schematic top view of a temperature equalization zone and shows the positions of the resistor heating elements.
- Fig. 3 shows a schematic cross-section taken through the temperature equalization zone.
- Fig. 4 shows the positions of the ~~thremocouples~~ thermocouples in the channel of the temperature equalization zone.
- Fig. 5 shows a block diagram of the electric control equipment.

INSERT DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 shows a longitudinal cross-section of a temperature equalization zone intended to equalize temperature differences in molten glass in the f rm f a channel 1 used to transport a glass melt. The ~~, said~~ zone ~~being~~ is located upstream from a tap-off point 2 at which the glass is tapped into a ~~mould~~ mold

(not shown) in a forming machine or the like. A cross-s ction of channel 1 is shown in Fig. 3. The channel is made of an appropriate ceramic material 3 such as aluminium oxide Al2O3. The channel can, for example, be about 1000 millimeters ~~millimetres~~ wide and have a depth of about 150 millimeters ~~millimetres~~. For such cross-sectional dimensions, the temperature equalization zone can be about 2000 millimeters ~~millimetres~~ long. Above the channel there is a roof 4 made of insulating refractory material, firebrick for example.

Beneath channel 3 there is additional insulation 5 in the form of, for example, firebrick. The entire temperature equalization zone rests on supports in the form of a steel beam 6. Above roof 4 there is also additional insulation 7, 8, in the form of firebrick for example.

A stopper plug 9 is provided to prevent glass melt 11 from entering into a tapping zone 10 that includes tap-off point 2. The tapping zone is made of an appropriate ceramic material such as aluminium oxide.

In accordance with the invention, resistor heating elements are provided in the walls 12, 13, bottom 14 and roof 15 of the temperature equalization zone, see Fig. 3. In Fig. 3, numbers 16-19 represent such resistor heating elements. These are of an appropriately known type, supplied by, among others, KANTHAL AB located in Hallstahammar, Sweden.

In accordance with the invention, the temperatures of the surfaces of the walls, bottom and roof, respectively, that are in contact with the resistor heating elements are measured, and said resistor heating elements 16-19 are controlled by an electric controller so that said temperatures of said surfaces are caused to be k pt equal or largely equal to a predet rmined tapping temperature of the glass melt.

The measurements ar mad using thermocouples 20-23 in the conventional way. Th rmocouples 20-23 can be separate from the resistor heating elements or, alternatively, they can be integrated with the resistor heating elements.

It is preferred to have the resistor heating elements spaced at regular intervals along the temperature equalization zone. This is illustrated in Fig. 1 where bottom elements 24-26 and roof elements 27-29 are spaced at regular intervals. The number 30 represents several thermocouples.

Fig. 2 illustrates the extent of roof and bottom elements 18, 19 (see Fig. 3) shown in a horizontal view. Fig. 2 also shows side elements 20, 21 (see Fig. 3) as circles. These are interspersed with the bottom and roof elements in the longitudinal direction of the equalization zone.

In accordance with a preferred embodiment, the temperatures of the surfaces of the walls, bottom and roof which contact resistor heating elements are caused to be measured as the temperatures of the respective resistor heating elements.

3bB2 In accordance with an embodiment, the resistor heating elements are spiral elements mounted in ceramic tubes on the outer surface of the ceramic material 3 that comprises said channel 1. It is this embodiment that is illustrated in Fig. 2 by circles 20, 21.

3bB3 In accordance with another embodiment, the resistor heating elements are band-shaped resistor elements that are mounted at the outer surface of the ceramic material 3 that comprises said channel 1. This embodiment is illustrated in Fig. 1 by elements 24-29.

The way in which the elements are formulated is not of importance with regard to the invention. What is important is that there must be a sufficient number of elements having suffici-

ently high power output to be abl t maintain a sufficiently high and predetermined temperature in the glass melt.

In accordance with a preferred embodiment, the temperatur equalization zone is caused to have a length which corresponds to at least 1-2 times the width of said channel.

An electric controller was mentioned above. A block diagram in Fig. 5 shows such a controller. Appropriately, the controller incorporates a microprocessor 31 with associated memory and software. All thermocouples are connected to the microprocessor via suitable input circuits so that the microprocessor therewith obtains a signal that corresponds to the temperature measured by the respective thermocouple. The microprocessor is designed to control, via control circuits 32-34 which include thyristors, each and every resistor heating element, exemplified as elements 16, 17, 19 in Fig. 5, either individually or in groups.

To summarize, there is thus an equalization zone that includes a large number of resistor heating elements that are regulatable so that channel 1 can be kept at a predetermined temperature.

As set forth above, the temperatures of the surfaces of the respective walls, bottom and roof contacted by the resistor heating elements are caused to be measured, and the resistor heating elements are caused to be controlled by ~~control~~ the electric controller so that the temperatures of said surfaces are caused t be kept equal or largely equal to a predetermined tapping temperature of the glass melt.

Experience has shown that if the walls contacted by the resistor heating elements are at the temperature that was predetermined for the glass melt, the temperature gradient, after an initial warm-up period in the temperature equalization zone, through the material 3 that forms the channel will

be zero or close to zero. This means that the inner channel walls will assume the predet rmined temperatur of the glass melt.

When the glass melt is transported to the temperature equalization zone, it has an average temperature that is close, or very close, to the desired tapping temperature, but the temperature is unevenly distributed through a cross-section of the glass melt taken at right angles to the transport direction of the glass melt. It is this uneven temperature distribution which gives rise to the problem mentioned in the introduction.

Immediately upstream from the tap-off point there are, arranged in a known manner, usually nine thermocouples 35-43 that form a matrix 44 located in channel 1 and used to measure the temperature distribution in the glass melt. Preferably, these thermocouples 44 are connected to the microprocessor. Consequently, the microprocessor can be arranged to issue an warning signal when the temperature distribution is not sufficiently uniform.

By means of the invention, the problem mentioned in the introduction is thus solved while providing a 10-15% increase in yield, as compared with a conventional temperature equalization zone. The main difference between using the present invention and a conventional method is that for a conventional temperature equalization zone the temperature of the inner surface of the channel is lower than the desired temperature of the glass melt.

Below are some examples of a practically conducted test.

The temp rature equalizati n zon was 2440 millimeters ~~millimetres~~ long. The channel was 1060 millimeters ~~millimetres~~ wide and 152 millimeters ~~millimetres~~ deep. Six bottom elem nts and six roof el ments were spaced at r gular intervals along the zone. Each element had a maxi-

mum power output of 2855 W. Six side elements were plac d along the two sides of the z ne and spaced at regular intervals. Each of these elements had a maximum power output of 595 W. The glass melt was transported in the channel at a speed of 10 millimeters ~~millimetres~~ per second.

Before the equalization zone was equipped with elements in accordance with the invention, the temperatures in said matrix 44 were as tabulated below in degrees centigrade (°C ~~oC~~). The values set forth below are for the positions shown in Fig. 4.

1166	1169	1166
1161	1175	1161
1153	1176	1153

The greatest temperature difference was thus 23°C ~~22oC~~.

After starting to use the invention, the corresponding temperatures were as follows.

1164	1166	1166
1163	1166	1162
1163	1166	1163

As these figures show, the greatest temperature difference was only 4°C ~~3oC~~.

Several examples of embodiments have been described above. However, it is obvious that the number of elements, the type of elements, the power outputs of the elements and the locations of the elements must be adapted to the temperature equalization zone in question. An expert, however, will have no difficulty in calculating the power output and the number of resistor heating elements needed to implement the invention in an existing or recently manufactured temperature equalizati n zone.

The existing invention shall therefore not be considered limited to what has been set forth above. Instead, it can be varied within the scope of what is set forth in the attached claims.